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**Abstract:** This paper explains the role and the main objectives of the GSE Forest Monitoring (GSE FM) Service Portfolio Evolution. This task supports the cardinal requirements of sustainability of the GMES (Global Monitoring for Environment and Security) services. In order to satisfy the needs of the stakeholder the requests for better and more complete information on environment and security the GMES services must continuously improved. The Service Portfolio Evolution is one of the key inputs for improved service provision. Throughout the entire services of the GSE FM Service Portfolio the interactive involvement within the process of production (in-situ measurements, data pre-processing, data classification, product accuracy assessment etc.) is the most cost and time efficient factor and is therefore be treated with high priority to research activities. The continuous identification of new RD therefore supports the sustainability of the GMES services and establishes common standards for all Service Providers and users.

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# SERVICE PORTFOLIO EVOLUTION – THE INSTRUMENT FOR KEEPING THE SERVICES OF GSE FOREST MONITORING UP TO DATE

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## ABSTRACT

This paper explains the role and the main objectives of the GSE Forest Monitoring (GSE FM) Service Portfolio Evolution. This task supports the cardinal requirements of sustainability of the GMES (Global Monitoring for Environment and Security) services. In order to satisfy the needs of the stakeholder the requests for better and more complete information on environment and security the GMES services must continuously improved. The Service Portfolio Evolution is one of the key inputs for improved service provision. Throughout the entire services of the GSE FM Service Portfolio the interactive involvement within the process of production (in-situ measurements, data pre-processing, data classification, product accuracy assessment etc.) is the most cost and time efficient factor and is therefore be treated with high priority to research activities. The continuous identification of new R&D therefore supports the sustainability of the GMES services and establishes common standards for all Service Providers and users.

**Keywords:** GSE FM, GMES, ESA, Forestry, Forest Mapping, Forest Cover Change Mapping

## 1 INTRODUCTION

Service Portfolio Evolution comprises the identification, testing, evaluation, harmonisation and implementation (into Service Portfolio Specifications) of new methods and standards. The activities undertaken in this task lead to an improvement of the processing flows by incorporating new operational data sources, processing algorithms and methodologies. Furthermore, it improves the service delivery on an expanded scale and leads to a mid-term reduction of costs within all GSE FM services. To fulfil these objectives the main activity under this task is the transfer of suitable mature R&D results and proto-type software from an existing group of cooperating research partners and projects into the operational production environment. This process of technology transfer involves an iterative process between the science group and the Service Providers (SP's) in terms of testing the new methods and algorithms before the inclusion into the Service Portfolio and service chain. In this context, a group of Scientific Experts was formed to identify any new research results from the above categories.

### 1.1 GSE FM: OVERVIEW

GSE FM is one element of the GMES (Global Monitoring for Environmental and Security) initiative of the ESA Earthwatch Programmes. GSE FM stage 2 started in 2005 with three year duration. The extending international consortium is led by GAF AG and started with 18 Service Providers and 25

End Users. Main goal is to deliver customised and policy-relevant and information mainly based on EO data in ready-to-use packages in the field of Climate Change, Sustainable Forest Management as well as in Environmental Issues and Natural Protection. The supplied products and services are validated and standardised to support decision-making and improved policies that enable cost effective sustainable forest management in various countries. To guarantee the GSE FM standards all products including their specifications and instructions for production are collected within the Service Portfolio Specifications (Häusler & Gomez, 2005).

### 1.2 GSE FM: SERVICES

The services and products are based on a wide set of forestry and environmental policies that range from highly accurate yearly carbon balance estimates and the compilation of forest disturbance data but also information products for practical forest and land use management operations such as:

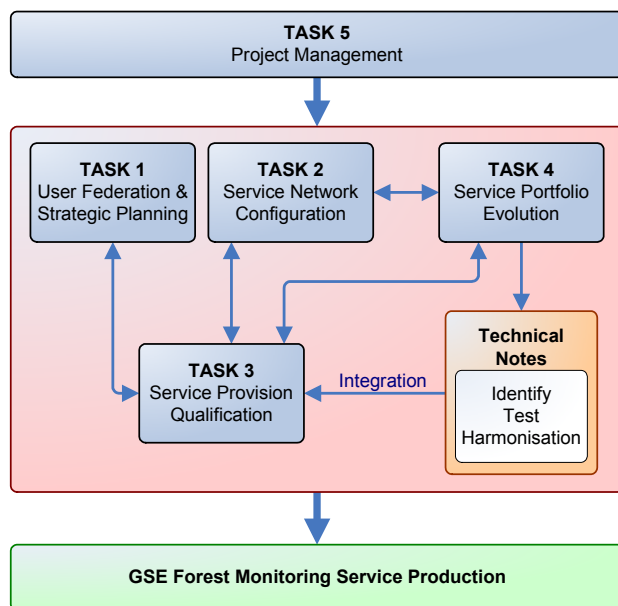
- Land use/cover and land use/cover change maps
- Forest cover and forest cover change maps
- Clear cut/disturbance maps and related databases
- Stand-type maps that support sub-national forest Geographic Information Systems (GIS)
- Forest fragmentation and structural diversity maps

- Stem volumes, biomass and carbon statistics and corresponding change data, as well as user-customised versions and/or combinations of the above.

### 1.3 GSE FM: POLICY AND TASKS

The GSE FM is one of the initial services of the GMES GSE's. The implementation Stage 2 aims to enhance the results from the consolidation Stage 1 in a period between 2005 and 2008. Each consortium has to maintain the overall GMES policy which follows four major cardinal requirements:

- Cardinal Requirement 1: Demonstrate progress towards long-term sustainability for a set of GMES services
- Cardinal Requirement 2: Deliver services and benefits to users on progressively larger scales
- Cardinal Requirement 3: Establish a durable, open distributed GMES Service provision Network
- Cardinal Requirement 4: Establish standards and working practices for GMES Services



**Figure 1.** Service Diagram of Tasks 1-5 in GSE FM.

The main objectives of the GSE FM Service Production to support and accomplish these cardinal requirements are divided into five tasks (Fig. 1):

- Task 1: User Federation and Strategic Planning
- Task 2: Service Network Co-ordination
- Task 3: Service Provision and Qualification
- Task 4: Service Portfolio Evolution
- Task 5: Project Management

Task 4 relates to the Evolution of the Service Portfolio and supports the cardinal requirement of sustainability of the GMES services (Cardinal requirement 1).

## 2 SERVICE PORTFOLIO EVOLUTION

### 2.1 OBJECTIVES

The scope of Service Portfolio Evolution is to provide Service Providers with updated and/or newly invented processing chains, methodologies or data sources for the production of sustainable and highly qualified products as requested by the users. The main objectives of Service Portfolio Evolution are:

- Identify, test, evaluate and transfer new R&D into the Service Portfolio Specifications
- Provide authority with results of R&D from research partners and wider R&D domains
- Transfer mature R&D results and prototype software from co-operating research partners and projects into the operational production environment by verifying the methods demonstrated on local test-sites
- Improve compliance with user-domain standards
- Improve operational efficiencies and contributing to the evolution of the Service Portfolio Specifications

Service Portfolio Evolution shall assess vulnerable or missing aspects in the service production chain (e.g. EO data, in-situ data) and propose sustainable solutions to reduce costs for all GMES services. Within this scope, the GSE FM services shall be continuously improved and SP's shall implement the recommendations provided with the upgraded Service Portfolio Specifications into their work procedure plan. Main emphasis shall be put onto the identification, test, transfer and integration of new research results that fit in one or more categories of the following to provide improvements for the Service Providers:

- Data: new EO operational data, in-situ and/or other data sources
- Production: software tools, algorithms, models, methods etc.
- Integration: technical innovations that improve integrity of the service chain
- Standards: implementation of standards at different levels in service production chain that improve compatibility, transfer, formats, outputs accepted by many users etc.

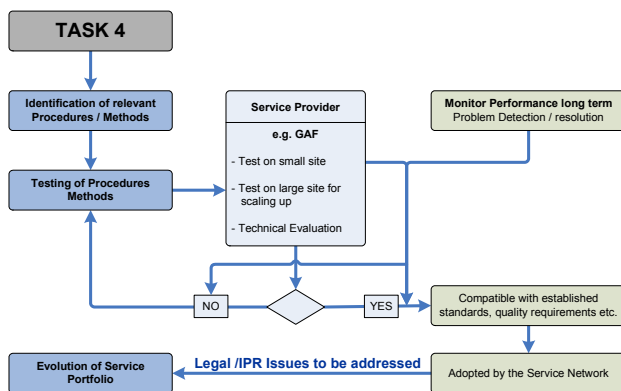
- Validation: any innovations that improve validation of verification of inputs, products or accuracy parameters etc.

## 2.1 IMPLEMENTATION

The Service Portfolio Evolution (Task 4) comprises three main activities which are as follows:

- Identification of new methods (WP 410)
- Testing of new methods (WP 420)
- Harmonisation, integration of new methods and standards (WP 430)

The main process of technology transfer in Task 4 involves an iterative process between the science group and the Service Providers in terms of testing the new methods/algorithms before inclusion into the Service Portfolio and service chain. These steps are illustrated in Fig. 2.



**Figure 2.** Process of technology transfer in Task 4.

The full thematic range of the Service Portfolio Evolution is subdivided into the following four categories:

- Methods and applications regarding EO SAR data
- Methods and applications regarding EO optical data
- EO and in-situ combined methods
- Kyoto policy feedback on IPCC guidelines and related topics

In this context, a group of scientific experts was formed to identify any new research results from the above categories. Each expert team is assigned to one of the categories.

## 3 EXAMPLES

Up to now (by end of phase 2) about 15 different contributions covering all of the above stated categories have been prepared. Proposed new methods

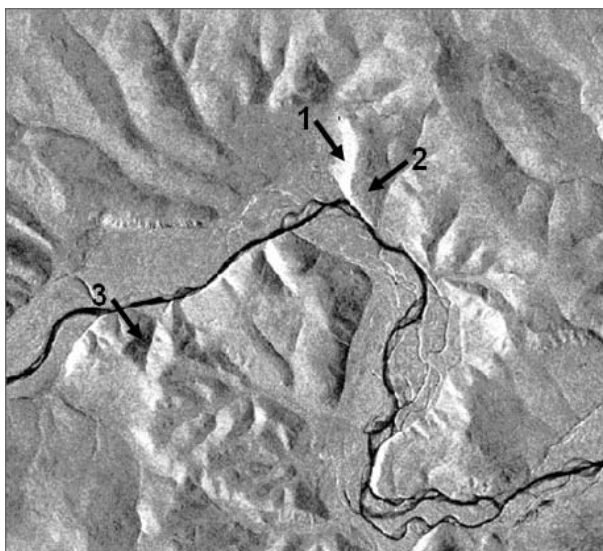
comprise amongst others topographic normalisation of optical and SAR data, implementation of new SAR data sources, resolution merge of optical data, approaches for automatic orthorectification of SAR data and enhanced methods for map accuracy assessment. In the following two examples are given.

### 3.1 TOPOGRAPHIC NORMALISATION OF SAR DATA

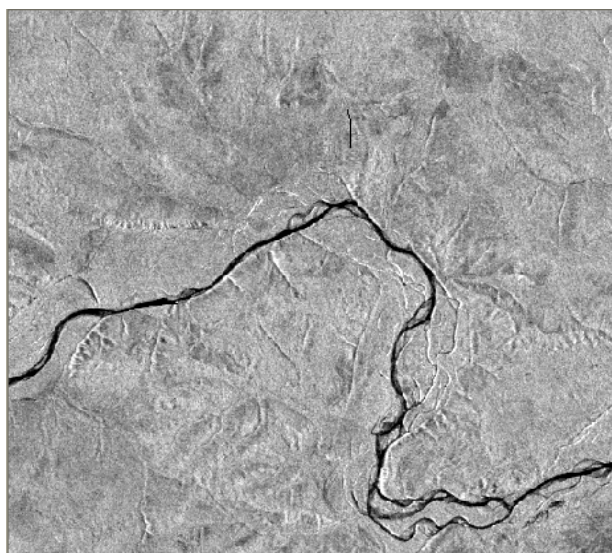
The effect of topography in SAR images becomes obvious in brighter image sections where slopes are facing the sensor (see area 1 in Fig. 3) and darker image sections where the opposite is the case (see area 2 and 3 in Fig. 3). At this subsection the land is completely covered with forest. Those effects are apparently hindering efficient forest cover detection as the dynamic range of the image is mostly driven by topography. The topography induced radiometric variations are caused by two effects: 1) variable ground scattering area creating calibration errors over sloping terrain and 2) variable local incidence angle that can modify the scattering mechanisms of a given surface type (Zyl et al., 1993). The SAR data pre-processing must therefore include the reduction of these effects. Stussi et al., 1995 developed a SAR processing chain for relief calibration and backscatter angular correction.

Figure 4 shows the same image after topographic normalisation. The efficiency of the algorithm is clearly demonstrated. After eliminating major topographic effects the main driver of the dynamic range of the backscatter is the land cover. Now, even diverse forest densities can be recognised. The algorithm was tested for a wide range of SAR sensor products (ERS, JERS, ASAR APP, ASAR IMP, ALOS FBS, and ALOS PLR) and different regions (Siberia, Germany, and Iran). All tests proved the value and the qualification of the proposed method. For all data sets high-quality results could be achieved. The separability between the desired classes could be drastically increased. Although the topographic normalisation introduces an additional work step into the SAR processing chain, which takes about 0.3 man hours, overall time can be saved due to increased classification efficiency. As the class signature spectrum is reduced less training samples have to be collected. Moreover, less post processing effort needs to be spent as the accuracy of the raw classification is higher. Consequently, topographic normalisation was proposed to be included into the Service Portfolio Specifications.





**Figure 3.** Subsection of ALOS PALSAR FBS HH scene (Siberia, winter) before topographic normalisation



**Figure 4.** Subsection of ALOS PALSAR FBS HH scene (Siberia, winter) after topographic normalisation

### 3.2 IMPLEMENTATION OF NEW SAR DATA SOURCES: PALSAR COHERENCE

SAR coherence was demonstrated being a valuable estimator of forest biomass (Israelsson et al., 1994, Leckie & Ranson, 1998, Askne & Santoro, 2005). Consequently, this technique can be also employed for forest cover and forest cover change mapping (Yatabe et al., 1995, Santoro et al., 2006). However, specific SAR sensor configurations (or constellations respectively) are required for accessing this opportunity. Using shorter wavelengths such as C-band requires also short revisit times (ERS-Tandem Mission). With increasing wavelength longer temporal baselines can be accepted. This is especially

true if stable ground conditions can be assumed, as found for example during the Siberian winter. E.g. JERS-1 SAR 44-day repeat pass coherence provided valuable input for forest cover mapping (Eriksson et al., 2005). Unfortunately no sensor providing appropriate coherence information for forestry applications was operational since 1998. This has changed with the launch of ALOS. Thus, a new potential data source for forestry applications is available and could be implemented into the Service Portfolio Specifications.

Up to now six high resolution PALSAR FBS HH image pairs have been investigated (Tab. 1). Fig. 5 provides an example. Clear-cuts can be easily recognised (orange). Also visible are variations in forest density (diverse shades of orange/green). At both acquisitions and during the time in between very stable weather conditions with temperatures below 0°C have been observed (at relevant climate stations). The perpendicular baseline is about 1,100 m.



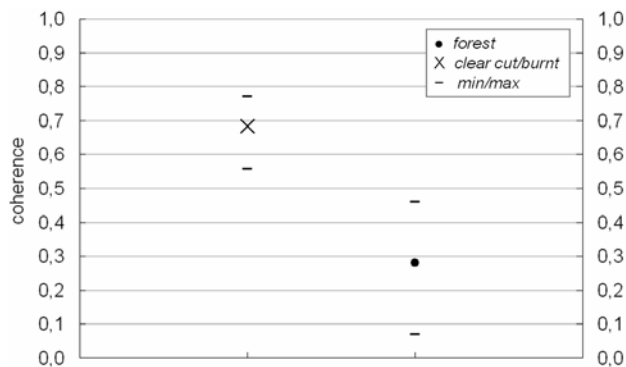
**Figure 5.** Subsection of ALOS PALSAR FBS HH coherence. RGB= Coh/Int/Ratio Int.

The data examination includes signature analysis and class separability computation. The coherence signatures (based on image objects) are given in Fig. 6. Non forest areas are much more stable (especially during winter) and thus exhibit clearly higher coherence measures. As there is no overlap between the signatures high separability can be assumed. This can be confirmed by the normalised Jeffries-Matusita distance (1.0 = signatures separable; 0.0 = signatures inseparable) values given in Tab. 1. At all cases the maximum is reached for the object based calculation (last column) and high values are achieved on pixel basis. Accordingly, ALOS PALSAR FBS HH winter coherence was proposed

to extend the EO data sources collected in the Service Portfolio Specifications.

**Table 1.** Coherence pairs and separability of burnt/clear-cut vs. forest

date	mode	position	separability: pixel/object	
27DEC06 11FEB07	FBS Coh.	56°84'N 104°16'E	0.99	1.00
27DEC06 11FEB07	FBS Coh.	57°33'N 103°99'E	0.99	1.00
13JAN07 28FEB07	FBS Coh.	56°84'N 103°62'E	0.98	1.00
13JAN07 28FEB07	FBS Coh.	57°33'N 103°45'E	0.98	1.00
01JAN07 16FEB07	FBS Coh.	56°35'N 102°69'E	0.98	1.00
01JAN07 16FEB07	FBS Coh.	56°84'N 102°54'E	0.99	1.00



**Figure 6.** Object based coherence signatures: forest vs. burnt/clear-cut (means = averaged values for all pairs, min/max = global min/max)

The above tested and assessed methods (EO SAR data in that example) will now have to be tested by the Service Providers who require these processes. If these tests are successful there will be a full incorporation of the methods into to production chains of GSE FM (Service Portfolio Specifications).

## 4 CONCLUSIONS

This paper presents the approach of Service Portfolio Evolution of GSE FM. This approach is applied since the kick off of GSE FM Stage II and conducted in an annual cycle. Thus, the Service Portfolio Specifications are continuously updated in terms of service extension and methodology refinement. This guarantees the supply of the Service Providers with updated and/or newly invented processing

chains, methodologies or data sources for the production of sustainable and highly qualified products as requested by the users. Thus, Service Portfolio Evolution is one of the key elements of GSE FM ensuring the deliverance of standardised and up-to-date products.

## ACKNOWLEDGMENT

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